

# ***The trans-Pacific HDR Satellite Communications Experiments***

*Achievement and Lessons Learned*

N. Kadowaki, N. Yoshimura and N. Nishinaga  
*Communications Research Laboratory  
Ministry of Posts and Telecommunications, Japan*

# General Objectives

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- **To construct the Global Information Infrastructure with satellite / terrestrial integrated networks utilizing advantages of each systems.**
  - \* To verify that the satellite communications systems are operable for HDR multi-media communication services in conjunction with terrestrial networks.
  - \* To verify that the satellite communications systems can play an important role to realize the GII.

# History of the Project

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- Nov., 1993 : Proposed in Japan-US Cooperation In Space Program Workshop in Hawaii.
- Nov., 1994 : Agreement in Japan-US Cooperation In Space Program Workshop in Hawaii.
- Feb., 1995 : Agreed to be one of GIBN projects at the G7 information society meeting in Brussels.
- *System investigation and preparing has been done.*
- Feb.7, 1997 : 45 Mbps end-to-end connection was established.
- Mar.28, 1997 : Public demonstration of remote HD video post-production application using the connection.
- Nov., 1997 : Agreed to proceed the Phase-2 experiments.
- Dec., 1999 : Started to prepare Phase-2 experiments.
- ***May 24 - Jul. 22, 2000 : Phase-2 demonstrations.***

# Achievements of Phase-1 Exp.

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- **We achieved DS-3 rate international ATM connection utilizing 2 satellite links and 3 terrestrial networks.**
  - \* Inter-operability of SDH, DS-3 and SONET was verified.
  - \* Sufficient ATM transmission performance was achieved.
- **We verified the application system operability over the link.**
  - \* Integration of post-production system and HDR communications network.
    - MPEG-2 encoded ATM transmission.
  - \* Public Demonstration was successfully performed on March 28 (JST).

# Advancement from Phase1 to Phase 2

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- **Higher Layer Protocols**

- \* Phase 1 : ATM-native

- Phase 2 : ATM + TCP/IP + Multicast / AFS

- **More Research**

- \* Technical trials and experiences for practical use in the future.

- Constructing global multimedia networks.

- Evaluating TCP/IP performance.

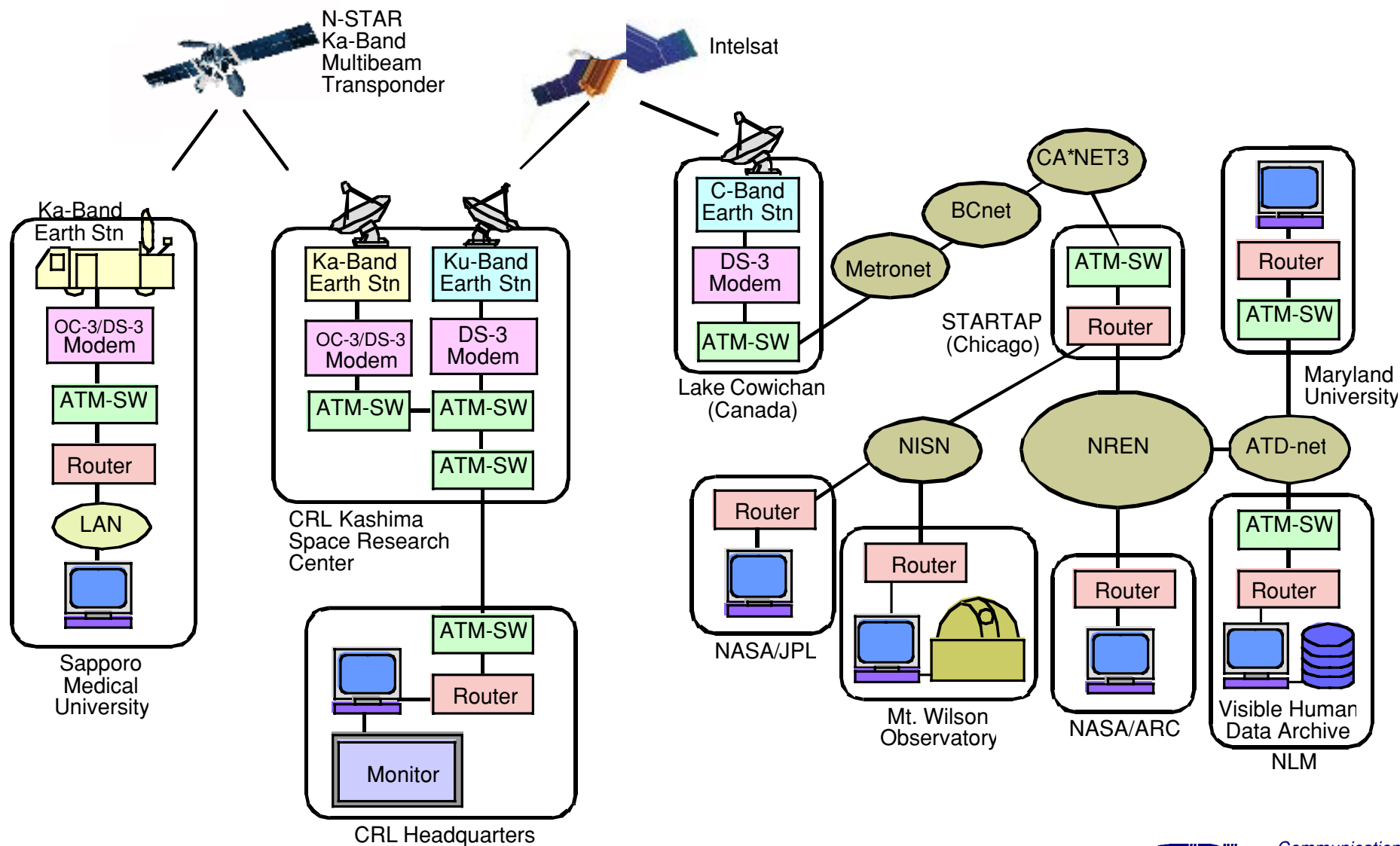
- Demonstrating flexible internet connectivity.

- **More Applications**

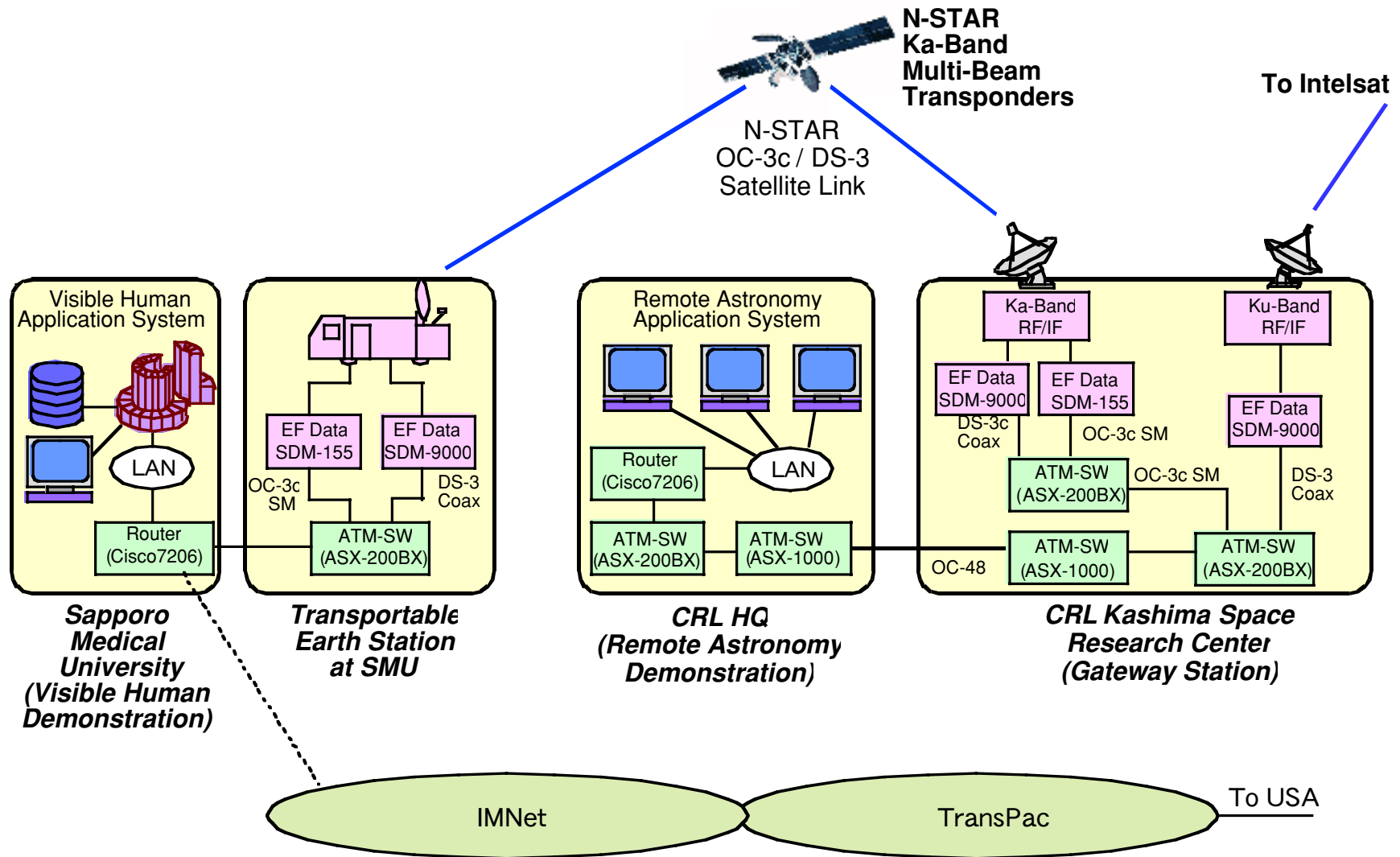
- \* More than transmission.

- \* Sharing huge amount of data in global scale.

# Network Configuration of Phase-2



# Japanese Network Configuration



# Transportable Earth Station

- *Installed at Sapporo Medical University*
  - \* *for N-STAR Ka-Band Multibeam Transponder.*
  - \* *can establish DS-3 / OC-3c links between KSRC & SMU.*



Tx Freq :	28.4 ~ 30.3 GHz
Rx Freq :	18.6 ~ 20.1 GHz
Antenna :	1.8 mφ
Tx Power :	150 W
IF Freq :	140 MHz
MODEM :	SDM-155 (8PSK, OC-3) SDM-9000 (OC-1, DS-3)
ATM-SW :	Newbridge 36150 OC-3(SM), DS-3(Coax), DS-1(Coax)
Pwr Consm :	17 kVA (200V, 3φ)
Weight :	4.2 t



# Preparation Status in Japan

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- Jan.22 - 23: Ship Ka-TES to SMU and Set up.
- Feb.22 - 25: N-STAR Link evaluation at ATM Layer. (DS-3 / OC-3c)
- Mar.22 - 25: TCP Performance evaluation over N-STAR. (DS-3)
- May 8 - 12: Install RA software and CUSeeMe at CRL-HQ.  
Establish OC-48 line between KSRC & CRL-HQ.
- May 15 - 19: RA software test via terrestrial line (Trans-Pac).
- May 24 - 26: Intelsat SSOG between LCW-01A & CRL-02G via POR802.  
Testing SkyX gateway between SMU & CRL-HQ via N-STAR.

# Engineering Experiments

*<Overview of Experiments>*

- **Objectives :**
  - \* Evaluating performance over satellite links
    - Influence of long delay, and burst error.
    - Multi-point connection in global scale.
- **ATM Transmission Performance Measurement**
  - \* Cell Error Performance
- **TCP/IP Performance Measurement**
  - \* Performance evaluation of RFC1323, 2018
  - \* Performance evaluation of XTP
- **IP Routing Flexibility**
  - \* BGP4 route switching test
- **AFS Performance Test**
  - \* Functionality of AFS as distributed file system environment.

# Technical Achievements (1)

## ***International Connectivity***

- **Bandwidth Issues**

- \* 27.3 MHz was allocated to the TPD. CRL borrowed SDM-9000 with 8PSK from Teleglobe to match this limitation.
- \* The DS-3 link quality was very good. (Error free)

- **ATM Connectivity**

- \* We could not obtain PVC connection for the first two weeks, but after the PVC assigned between Japan and the US we have no significant problems.

- **IP Connectivity**

- \* We tried to use BGP-4 routing control scheme in order to switch the connection between terrestrial route and via-satellite route. BGP-4 was applied to the routers at CRL HQ, SMU and BCnet. Once we had IP connection over ATM link, BGP-4 worked very well.

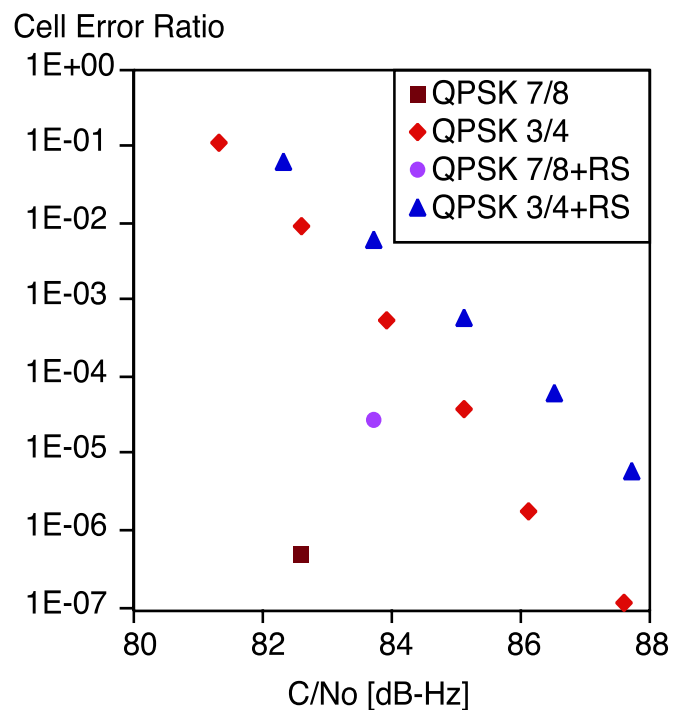
# Technical Achievements (2)

## ***Domestic Connectivity***

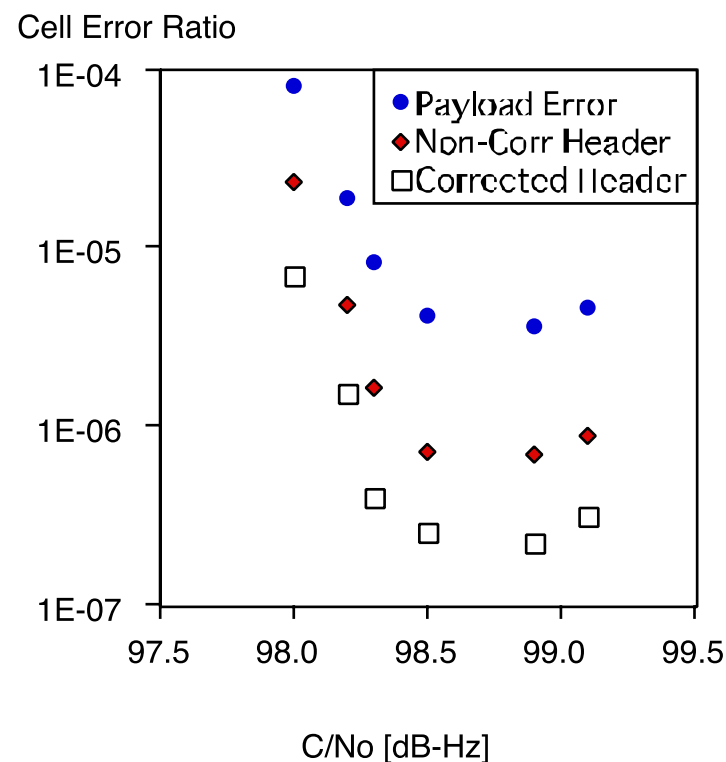
- **Connectivity between KSRC and SMU**
  - \* JSAT owned N-STAR's Ka-band multibeam transponder was utilized to connect KSRC and SMU. The transponder has the bandwidth of 200 MHz and we can obtain OC-3 or capacity with that transponder. CRL installed Ka-band transportable Earth station at SMU in January, 2000 and tested the link quality in February and March. The cell error performance, TTCP performance and ftp performance are shown in the following view graphs.
- **Connectivity between KSRC and CRL-HQ**
  - \* Optical link was used to link KSRC and CRL-HQ and the capacity allocated to this project was 155.52 Mbps. This link was stable and error free during the demonstration period.

# ATM Cell Transmission Performance via N-STAR

45 Mbps

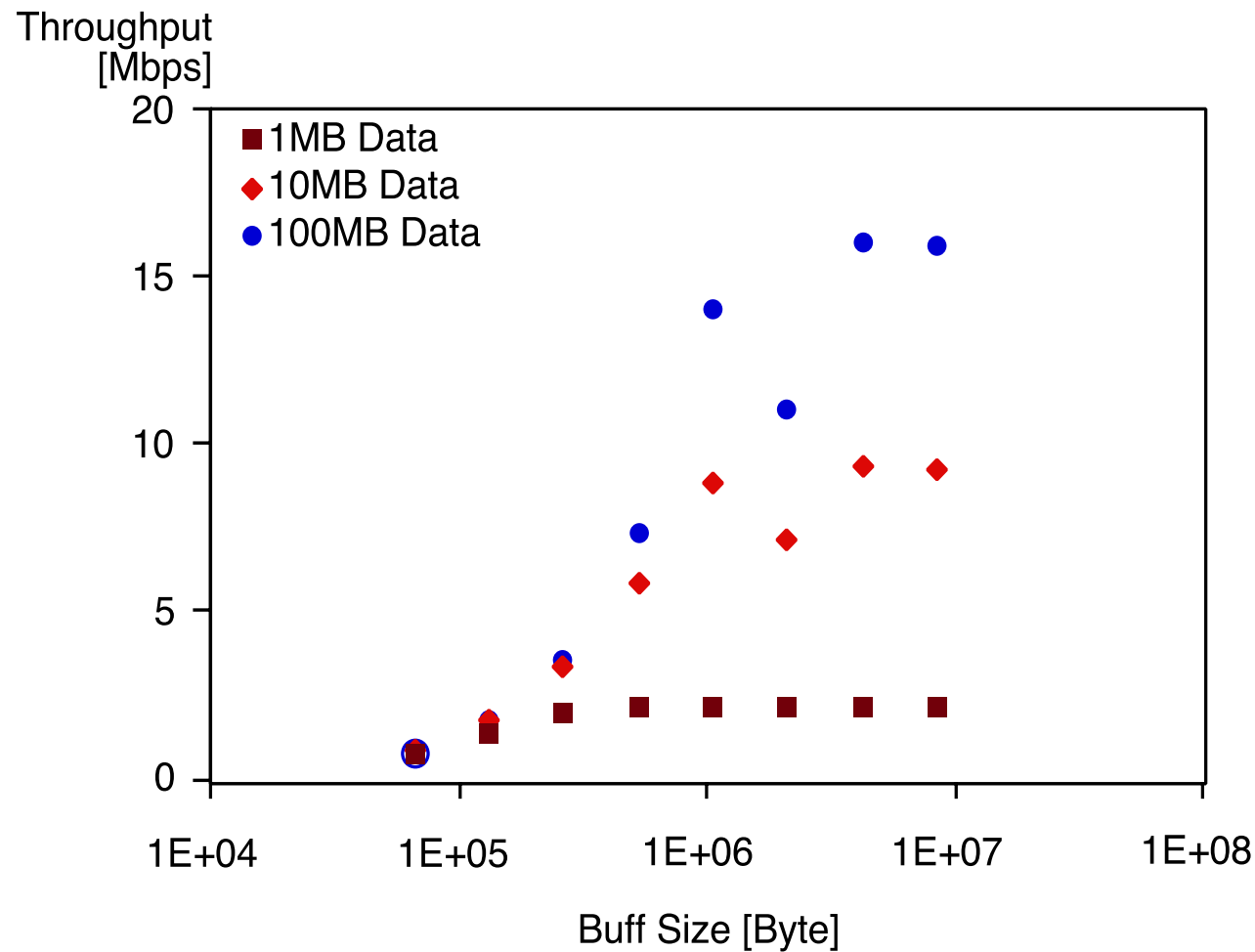


155 Mbps



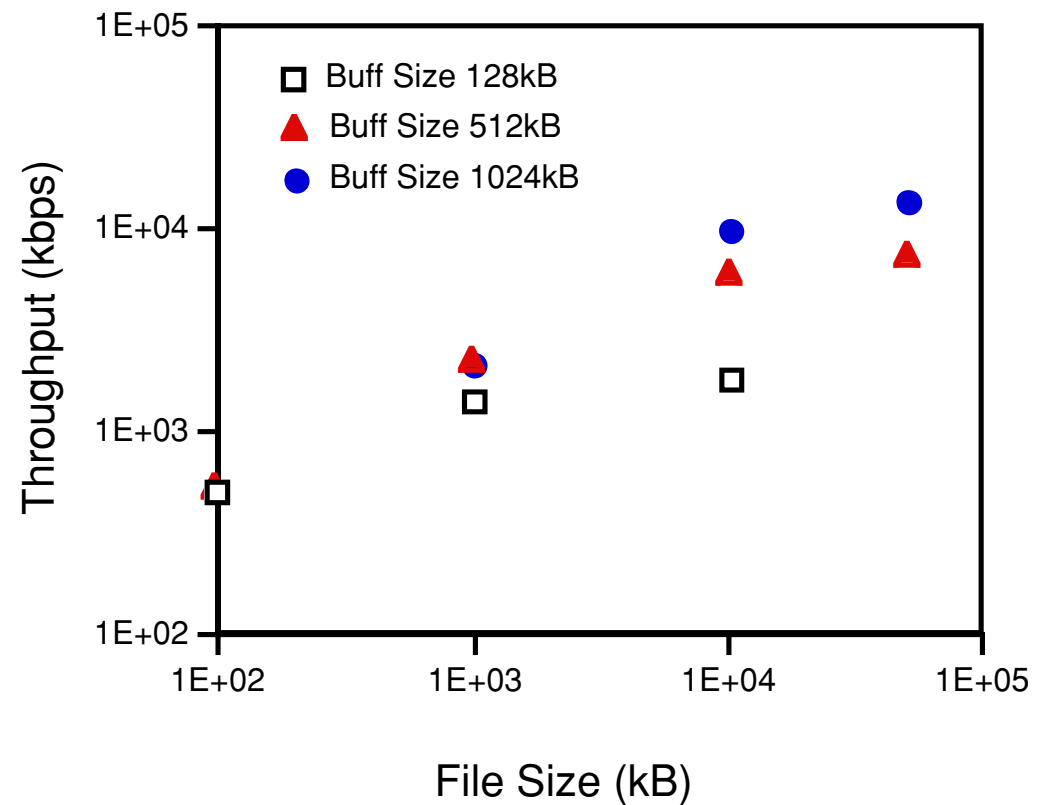
# TTCP Performance via N-STAR

## TTCP via N-Star (45 Mbps, Error-Free)



# ftp Performance via N-STAR

- KSRC : IRIX 6.3
- SMU : LINUX 2.2.7
- RFC-1323 : On
  - \* Buff Size : 128k, 512k, 1024kB
- N-STAR : DS-3
  - \* Error Free



# Application Demonstrations

## <Overview of Experiments>

- **Remote Astronomy Demonstration**

- \* Main Objectives

- To establish a remote astronomical observation system for distance learning and collaborative discussions.
    - To demonstrate the effectiveness of modern broadband satellites using multicast applications.

- **Digital Library Demonstration (Visible Human)**

- \* Main Objectives

- Biomedical image collaboratory between Sapporo Medical University (Japan) and NLM (USA).

- \* Huge Database Sharing and Interactive Processing

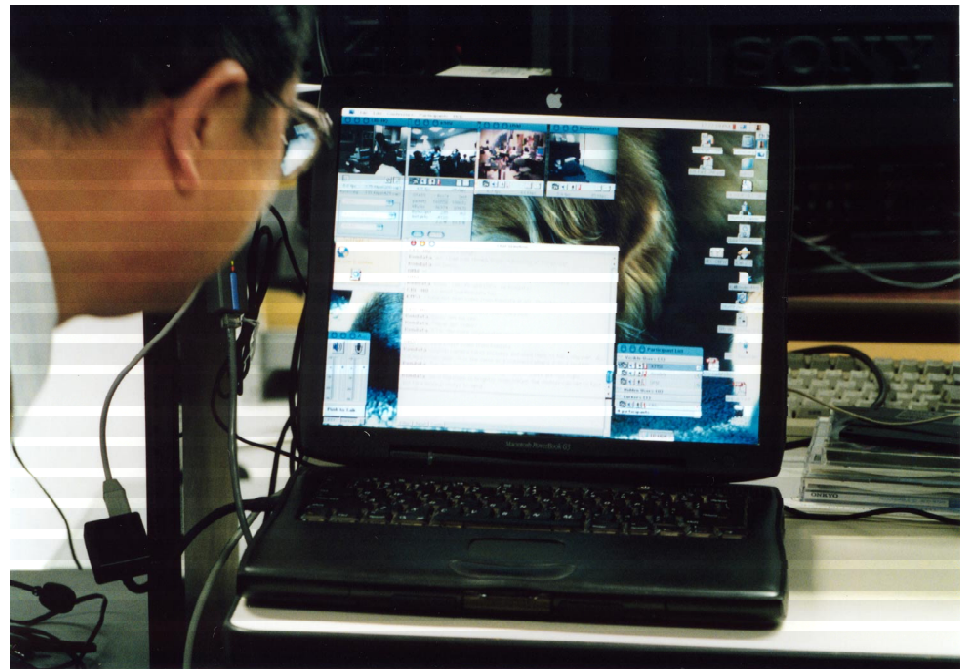
- Visible Humans Datasets
      - Male : 15 GB, Female : 40 GB
      - Growing Database as The Anatomical Datasets.
      - Centralised Repository and Managements : Licensing, Updates...
    - Proof of concept of a prototype system for interactive biomedical image segmentation, labelling, classification, indexing system.



# Remote Astronomy Experiments (1)

## *Multi-site Conferencing System*

- Implementation of H.323  
<CuSeeMe>
  - \* Multi platform based application implemented and worked fine.
- Testing high quality Video Conferencing System  
<ISABEL>
  - \* ISABLE is installed on SGI IRX machines locally in CRL and tested. (640 x 480 resolution)
  - \* ISABEL was not use oin the demo because of platform dependency. (Problems of version compatibility and platform compatibility.)



# Remote Astronomy Experiments (2)

## *AFS File Sharing*

- Operation

- \* File saving to server at ARC and file retrieving from server at ARC could be done at CRL-HQ.
- \* Mirror server at CRL-HQ could not be operated because of file system failure of the server machine.

- Performance

- \* It takes about 2 minutes to retrieve a file.



# Remote Astronomy Experiments (3)

## ***Demonstrations***

- July 1, 2000
  - \* Soka High School teachers experienced the remote astronomy environment.
- July 8, 2000 (right after the Typhoon passed)
  - \* Soka High students joined the demonstration.
    - Virtual class room with Crossroads high school.
    - Experienced internet-base tele-meeting.
    - Interactive instructions (lesson) regarding observing objects by astronomy experts.
- Effectiveness to raise students' interests was made clear.



# What We Learned from New Experiences (1)

## ***Technical Issues***

- RFC1323 and RFC 2018 basically works well to improve throughput performance over long-fat pipes such as HDR satellite links.
- Not all applications can utilize the advantages of RFC1323 and RFC 2018.
- XTP (SkyX) can improve throughput performance for links which bandwidth-delay product is known.
- AFS can provide shared file operation for wide spread users in global scale.
  - \* Throughput improvement with RFC1323 & RFC2018 could not be verified.
- NFS, PFS and some other networked file systems may have issues for utilize RFC 1323 & RFC 2018 advantages.
  - \* Networked file system employing ftp-based file distribution method can achieve better throughput in the environment when SkyX works well.

# What We Learned from New Experiences (2)

## *Management Issues (1)*

- **Project Management**

- \* CRL managed all activities of Japanese side.
- \* Information flow was relatively well.....
  - though everyone was too busy to do the tasks rapidly.....
- \* Preparation was delayed by some management issues such as station license, facility replacement in experimental site, etc. (Long term scheduling issue)
- \* Experiment scheduling was relatively done well by tele-conf week by week.
- \* RA demonstration was done without any press or outside observers because the schedule was very tight. (no time to announce)
- \* VH demonstration was done with press, and it leads following interests.

# What We Learned from New Experiences (3)

## ***Management Issues (2)***

- **Intelsat Link Operation**

- \* Station License : Experienced difficulties because of experiments using commercial transponders (shared).
- \* SSOG : Done by cotract with KDD. (New experience for CRL)
- \* Operation : CRL's researchers operated. 24 hour operation required very heavy load for researchers.

- **N-STAR Operation**

- \* Staff allocation : Needed to send a operator to SMU. (Budget issue)
- \* Operation : Long hour operation was very heavy loads for CRL staff. (Organization issue)



# Participants of The Experiments

- **United States**

- \* Apple Federal Systems
- \* ATDNet
- \* George Washington University
- \* NASA Headquarters, Ames Research Center (ARC), Glenn Research Center (GRC), Goddard Space Flight Center (GSFC), Jet Propulsion Laboratory (JPL)
- \* NASA Research and Education Network (NREN)
- \* National Science Foundation (NSF)
- \* Mentat Inc.
- \* Mt. Wilson Observatory
- \* National Institute of Health
- \* National Library of Medicine (NLM)
- \* Pacific Bell
- \* Science, Technology and Research Transit Access Point (STAR-TAP)
- \* Thomas Jefferson High School, Maryland
- \* University of Maryland
- \* White House National Economic Council

- **International:**

- \* Asia Pacific Advanced Network (APAN)
- \* Intelsat
- \* Japan-U.S. Science Technology and Space Cooperation Program (JUSTSAP)
- \* TransPac

- **Japan**

- \* Communication Research Laboratory (CRL)
  - Headquarters / Kashima Space Research Center
- \* IMnet
- \* Japan Gigabit Network
- \* JSAT Corporation
- \* Kokusai Denshin Denwa Company (KDD)
- \* Ministry of Posts and Telecommunications (MPT)
- \* Nippon Telegraph and Telephone Corporation (NTT)
- \* Telecommunications Advancement Organization (TAO)
- \* Sapporo Medical University (SMU)
- \* Soka High School

- **Canada**

- \* AT&T
- \* BCnet
- \* CANARIE
- \* Communications Research Center
- \* Metronet
- \* Teleglobe Inc.